that his/her monozygotic twin and a 39% chance that a dizygotic twin will also be dyscalculic. The link also exists between dyscalculics' parents and siblings: around half of the all first-degree family members of a dyscalculic also have dyscalculia (mothers, 67%; fathers, 41%; brothers, 53%; sisters, 52%), and 43% of the second-degree relatives. This prevalence is around tenfold higher than expected for the general population. However, there are no gender differences.

Is there any comorbidity with other developmental problems? People that have developmental problems, such as dyslexia, attention deficit hyperactivity disorder (ADHD), neurological problems, such as epilepsy, or genetic disorders of the X chromosome, are at greater risk than the normal population of being dyscalculic. In these cases, however, the dyscalculia might be a secondary problem, and might not stem from a core deficit for numerical processing *per se*. For example, a child with ADHD might not be able to solve arithmetic problems successfully due to failures in planning and organisation.

Aside from comorbidity with other developmental problems, it has also been suggested recently that people suffering from dyscalculia might have impaired abilities in processing other non-numerical magnitudes such as physical size.

What is the consequence of dyscalculia for one's life? The consequences of poor numeracy in today's world are significant and long-lasting: initial problems in school subjects that require maths later translate into reduced employment opportunities. Not surprisingly then, poor numerical abilities correlate with an adult's economic and social status and psychological well-being (it is no coincidence that all the happy, wealthy readers of *Current Biology* are above normal in their numerical abilities). Surprisingly, for women, deficiencies in numerical abilities can count even more than other disorders, such as poor literacy.

Can it be alleviated? In contrast to dyslexia, where the neurobiological basis has been convincingly demonstrated and some effective treatment possibilities have been introduced, remediation for dyscalculia is in its infancy. There are some current attempts to design training programs, including adaptive computer games for children, which will hopefully enable us in the long run to remediate dyscalculic behaviour. However, remediation programs still need to be validated in large group trials including a control group in order to examine placebo-like effects. The future success of remediation programs rests on accurate and early diagnosis of subtypes of dyscalculia, and referring the person to the appropriate intervention program. Hopefully, better knowledge of both normal and abnormal numerical processing at the cognitive and anatomical levels, together with intensive focus on the genetic and molecular basis of dyscalculia, will provide effective solutions and consequently a better future for people suffering from dyscalculia.

Where can I find out more?

Ansari, D., and Karmiloff-Smith, A. (2002). Atypical trajectories of number development: a neuroconstructivist perspective. Trends Cogn. Sci. *6*, 511–516.

Butterworth, B. (1999). The Mathematical Brain (London, UK: Macmillan).

Cohen Kadosh, R., Cohen Kadosh, K., Schuhmann, T., Kaas, A., Goebel, R., Henik, A., and Sack, A.T. (2007). Virtual dyscalculia induced by parietal-lobe TMS impairs automatic magnitude processing. Curr. Biol. *17*, 689–693.

Gersten, R., Jordan, N.C., and Flojo, J.R. (2005). Early identification and interventions for students with mathematics difficulties. J. Learn. Disabil. *38*, 293–304.

Geary, D.C. (2004). Mathematics and learning disabilities. J. Learn. Disabil. *37*, 4–15.

Isaacs, E.B., Edmonds, C.J., Lucas, A., and Gadian, D.G. (2001). Calculation difficulties in children of very low birthweight. A neural correlate. Brain *124*, 1701–1707.

Parsons, S., and Bynner, J. (2005). Does Numeracy Matter More? (NRDC: London).

Shalev, R.S. (2004). Developmental dyscalculia. J. Child Neurol. *19*, 765–771.

Wilson, A.J., Revkin, S.K., Cohen, D., Cohen, L., and Dehaene, S. (2006). An open trial assessment of "The Number Race", an adaptive computer game for remediation of dyscalculia. Behav. Brain Funct. *2*, 19.

Institute of Cognitive Neuroscience and Department of Psychology, University College London, 17 Queen Square, London WC1N 3AR, UK.
E-mail: r.cohenkadosh@ucl.ac.uk

Essay

Alas for Volapük

Walter Gratzer

Dr Johnson deplored the loss of any language, for 'languages are the pedigrees of nations'. Is there then cause for regret in the evanescence of everything but English from the literature of science? Has the culture of science been impoverished by an erosion of long and proud traditions? At intervals throughout the last century national academies, afflicted by chauvinistic tremors, would undertake to cleanse their language of alien contamination. A notorious case was the attempt in Nazi Germany to expunge all words with Greek and Latin stems from the language of chemistry. Thus chemistry itself was to become 'separation craft' (*Scheidekunst*), a microscope a smallseetool (*Kleinsehwerkzeug*), capillarity hairtubulepower (*Haarröhrchenkraft*), and so on. This was taking to an extreme the literal character of the language in general (invented, Mark Twain thought, by a maniac), in which a vacuum cleaner is a dustsucker, a bra a bosomholder and braces (or, in the North American dialect, suspenders) are trouserbearers. Needless to say, though, the prescriptions were resolutely ignored by the scientists, and the attempt was never repeated. The French academy underwent its own, more decorous, linguistic convulsions, as when in the 1960s, after long deliberation, it affirmed that an enzyme was indisputably feminine (*une enzyme*), even if to all biochemists it was masculine, and has apparently remained so. There was also a kind of social distinction between those — the traditionalists, content that the French for DNA should be ADN and NMR RMN — and the modernists, who had done time in America and would refer to '*le DNA*'. In England there has been less concern over such abstractions, but some biologists, such as Peter Medawar, inveighed against the absurdity of complicated Latin locutions,

where Anglo-Saxon would have done — pseudopodium was one of many that irked him.

Ancient languages still in use, that needed to adapt to modern times, generated problems of their own. In Israel and in the Vatican committees sat (and no doubt still sit), charged with finding translations for technical terms. I have been told, by way of example, that the Hebrew for a back-axle is *ha backaxle*, while that for a front axle is *ha frontbackaxle*. There are now expressions in Latin for such terms as a pistol (a *manubalistula*, or hand-catapultlet), and for television (a long locution, terminating in *per electricitas undas*), and one must presume that the Pope by now has at hand the Latin for polymerase chain reaction. The Vatican may be the last sovereign state, besides the Anglo-Saxon countries, to continue using its own language for official scientific utterances.

The linguistic difficulties in fact began when, in the course of the 18th century, the primacy of Latin as the universal medium of scholarly communication began to fade. Newton's works, for instance, were being translated into all the major European languages, and the demotic tongue began to supplant Latin in university lectures. By the 19th century scientists had a Tower of Babel to contend with. Matters were not helped by the nationalistic contagion that spread even into science. Here is the French Minister of Education, writing in mid-century: 'Does not our tongue appear especially suited to the culture of the sciences? Its clarity, its sincerity, its lively and at the same time logical turn, which shifts ever so rapidly between the realm of thought and that of feeling. Is it not destined to be not merely scientists' most natural instrument but also their most valuable guide?' Well, certainly not in Germany, where gallophobia was already rampant. A noted organic chemist, Hermann Kolbe, was one who furiously denounced all things French: as to chemistry, he insisted, there was not a single institution of learning in all of France that could compare with even the humblest of the German universities. He was most of all incensed by his French confrère, Adolphe Wurtz, who had laid claim to chemistry as a French science, founded by Lavoisier, 'of immortal memory'.

This contumely intensified during the Franco-Prussian conflict and rose to a hysterical pitch during and in the years following the Great War. Pierre Duhem (of the Gibbs-Duhem equation), a formidable intellectual, formulated the notion that the Gallic and Teutonic minds are fundamentally dissimilar: the one embodies *l'esprit de finesse*, which gives birth to fresh concepts, the other only *l'esprit géométrique*, which can do no more than elaborate what *l'esprit de finesse* has wrought. Such theories were to surface in far more pernicious form fifteen years later in Germany, with the rise of the *Deutsche Physik*, the *Deutsche Mathematik*, and other such aberrations of the Nazi ideology, as well as in Soviet Russia.

At the end of the Great War, obloquy rained down on German scientists, in which the British also took a hand. Here is Lord Walsingham, writing in *Nature* in 1918: 'To those Germans, if any there be, who are honestly well disposed, and who put the interests of science before the greed for world domination, it can be no hardship to publish their descriptions in the English or French language, with which the great majority of their scientific workers are more or less intimately acquainted.' This of course was sheer spite, for his Lordship must have known that Germany led the world in many branches of science, that all scientists in the English-speaking countries would have had to master German, and many of the best had spent time in German laboratories as an indispensable rite of passage. (In fact, up to 1933, the year that marked the start of the Third Reich, Germany had bred more Nobel laureates than Britain and France together, and more than three times as many as the United States.)

For all that, there had long been an undercurrent of concern about the number of languages in which science was being taught, written and spoken at conferences. Should there not be a return to a single scientific language to reclaim the function that Latin had served through so many centuries? The leading proselytiser for such a scheme was Frederick Donnan — he of the Donnan effect — Professor of Physical Chemistry at Liverpool and later University College London. 'The problem', he declared in a letter to *Nature* in 1922, 'is a very pressing one'. He had, he related, attended in the past year several international conferences at which there were talks in English, French, German and Italian, and he had observed on these occasions that whenever the language changed, half the audience had got up and headed for the bar. For his part, he continued, he could manage the German well enough, but on hearing Italian or 'Parisian French', he too had been seized by an insistent thirst. He was pleased that 'the civilised world is at last beginning to take a real interest in the problem', for, following discussions at the annual meeting of the British Association for the Advancement of Science in 1919, a committee had been set up 'to study the practicability of an international language in science'.

The committee, Donnan informed the readers of *Nature*, had reported in September of 1921, and had taken the same view. Their conclusions were, first that 'Latin is too difficult to serve as an international auxiliary language'. Secondly, that 'the adoption of any modern national language would confer undue advantages and excite jealousy' (which one could readily imagine). And finally: 'Therefore an invented language is best. Esperanto and Ido are suitable; but the Committee is not prepared to decide between them'.

The idea was not in fact new, for around the start of the 20th century a return to Latin in scientific discourse had been seriously advocated. Then, in 1910 a document (later translated into English by Donnan) was disseminated by a group of scientific notables, among them the physical chemist, Wilhelm Ostwald and the mathematician, Louis Couturat. It had the title, *International Language and Science*. That there was a crisis, the protagonists thought, was

beyond question. 'It is required or supposed', a learned professor from Austria maintained, 'that every scholar or man of science should know at least German, French and English. For the majority of German scholars and men of science this may hold good, but in the case of the French it is less true, and in the case of the English least of all'. Little, then, has changed and the Americans are not even mentioned. But to continue, 'The knowledge of these three languages is, however, no longer sufficient'. How so? Why, because 'many Italians write only Italian, many Dutchmen only Dutch, whilst numerous Russians, Poles, Czechs, Hungarians, Scandinavians and Spaniards employ only their national languages. In this way much escapes general knowledge and recognition, or is only accessible in a belated or mutilated form.' This was true enough. Vitamin research, for example, was seriously retarded because the discoveries relating to beriberi and the B vitamins were published in Dutch, and not even abstracts were available to researchers in England.

Another contributor, a professor from Zurich, then gets to grips with the problem. Why, he asks, has one of the artificial languages, then in their heyday, not been embraced by the scientific community? What about Volapük, Esperanto, Neutral Idiom, Novilatin and Universal? Attempts, it transpires, had been made, and scientific books had even been written in Esperanto and Volapük. But how could one express scientific concepts with a vocabulary in which *vol* is world, *puk* is language and *Melop* is America? Out, then, goes Volapük, and Esperanto fares no better; the professor sees it off with an example: 'A rotary transformer might be called a motor-generator, but the latter name is usually applied to machines with independent armatures'. Rendered into Esperanto this becomes: *Turnighan alispecigilon oni provas nomi motorproduktanto*, which translated back into English emerges as, 'A self-turning otherwise-making instrument can be called a motor-producer'. After an analysis of what has gone wrong, the writer concedes that 'one cannot expect that such a gigantic task as the introduction of an international auxiliary language can be accomplished all at once'. The grounds for dismissing Esperanto seem perhaps a little unfair; I recall hearing in the early days of machine translation of a small but telling example of the pitfalls in the path of accuracy: the 'water goats', repeatedly alluded to in the translation of a paper from a Russian engineering journal, turned out to be hydraulic rams. At all events the writer in 1910 was not altogether downcast. 'We hold', he concluded, 'that Ido represents the first artificial language concerning whose introduction into science serious discussion is possible. We may state with full confidence today that …. the attempt to carry this out will be crowned with success.'

Yet in the middle of this dissertation there appears the ominous acknowledgement that 'national sentiment forces the scientific men of these countries [all but France, Germany and Britain] to use the national languages, even when they perceive that this procedure does not conduce to mutual understanding. Even if the scientific men themselves were completely free from national amour propre, they would be obliged by their fellow-countrymen to employ their own languages …' Therein probably, and perhaps also in mere inertia, lies the reason why the whole quixotic enterprise quietly disappeared from view despite Donnan's stirring appeal in 1922. Scientists, in any case, cherished as much as the literati the idiosyncrasies of their language. For the next half-century a protein in Germany remained an egg-white (as in the Max-Planck Institut für Eiweiss- und Lederforschung), and within the confines of the laboratory hydrogen is today still water-stuff, oxygen sour-stuff (no more a misnomer than *oxygène* itself, from the Greek for acid), nitrogen choke-stuff, and hydrocarbons coalwater-stuff. The symbol for iodine is J (*Jod*), and the Hungarian, Albert Szent-Györgyi recalled a jingle from his time as a medical student: *Wenn du nicht weisst was, warum/Gebe dann Jodkalium* – When you don't know what or why/Give your patient some KI. The French retain a preference for *azote* over nitrogen, and a control remains a witness (*témoin*). The French, in fact, tried hardest to resist the advancing tide. Twice, in the 1960s and again in the 1980s, French scientists were enjoined by their Government to deliver conference lectures only in French, no matter where, on pain of losing their support. It was a principle honoured only in the breach, never in the observance, and what its reception might have been, especially in America, was never seriously tested.

National journals in the national language still exist, but they command no attention outside their own countries, and probably little enough there. Even such venerable organs as the *Comptes rendus de l'Académie des sciences*, the *Berichte der Bunsengesellschaft*, the *Biochemische Zeitschrift* and many more, threw in the towel and switched to English. An international synthetic language surfaced briefly once more in the two decades after World War II, when a few journals (including American ones) appended to each paper an abstract, with the title *Summario in Interlingua*. Interlingua was not new. It was a macaronic concoction, closest probably to Spanish, with rudimentary grammar, and remarkably easy to follow. But it did not endure, and English, almost imperceptibly — because such a large proportion of science is now based in America, and because scientists in the rest of the world want the Americans to read their papers — became Donnan's international (not even auxiliary) language of science. Only fossilised vestiges of other tongues remain — Greek and Latin of course, and such curious hybrids as eigenvalues and eigenfunctions. Chekhov asserted that 'there is no national science, just as there are no national multiplication tables'. Perhaps he was right, but a little of the flavour has gone out of the profession all the same.

King's College, Randall Division of Cell and Molecular Biophysics,
New Hunt's House, Guy's Campus,
London SE1 1UL, UK.
E-mail: wbg@helios.rai.umds.ac.uk